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THE EDUCABILITY OF THE PERCH.

By NORMAN TRIPLETT.

The material here presented is a brief summary of observations made in the spring of 1899 on the psychic life of fishes in captivity. Its chief interest lies in its being a modified repetition of the famous experiment of Möbius which has come to be regarded by some as one of the fairy tales of science. Bateson's account of the experiment is as follows:¹

"The story runs that pike, having lived for some time in a tank separated by a glass plate from another in which small fish were living, desisted from trying to catch them, and on the glass plate being removed never attempted to do so. The suggestion is that the pike had come to believe these particular fish to be under special protection."

In the experiment to be detailed herein, two perch (*Perca Americana*), one of each sex, took the place of the pike. These fish had been kept in the laboratory in a tank, 4x2x1½ feet in size, for several months previous to the test given below. During all this time their only food had consisted of live minnows two or three inches in length. On beginning the experiment a glass partition was placed in the tank and their food changed to angleworms.

Instead of permitting the minnows to remain in the divided tank as Möbius did, I simply put them in for thirty minutes, and at the end of that time removed them again and gave the perch an allowance of worms. Experiments were made in this manner three times a week for nearly a month, on Mondays, Wednesdays and Fridays between the hours of four and five o'clock in the afternoon, and after that on every day at the same hour. In all experiments after the very first the observations were made from behind a screen through a narrow slit.

The notes taken on the various occasions would tell the story most completely, but to avoid unnecessary repetition, they have been condensed in the description following. On April

¹ W. Bateson: The Sense-Organs and Perceptions of Fishes, *Journal of the Marine Biological Association*, N. S. 1890, I, 225-256; see especially p. 243. The original account by Möbius in the *Zeitschr. Gesammt. Naturwiss.*, XLII, 1873, pp. 89-91, has, I regret to say, not been accessible to me. The same experiment is cited by Darwin in the *Descent of Man*, pp. 75-76, with a reference *Die Bewegungen der Thiere, etc.*, 1873, p. 11.

21st, the first day, I note: Two minnows were placed in the tank at 4.30 P. M. The perch immediately began ramming the glass to get at them. Their actions became more violent as the minnows approached the partition. They ceased their butting and swam away from the glass for a few seconds after seven minutes of continuous effort. A second trial lasting one minute followed, and this was followed in turn by still shorter periods. Greater energy was shown always when the minnows turned their heads toward the perch, as it is only when they are "head on" that the latter strike. At 4.55 the female was showing what seemed to be signs of anger, and was striking the glass hard. During all the subsequent trials she was the more persistent of the two, and several times seemed to show signs of rage, lashing the glass partition savagely. By five o'clock both perch had left the glass and seemed to have given up the attempt completely. At this stage the minnows were removed and the perch fed.

At the next trial their efforts were not so long continued nor so violent as on the first day, and the further history of this part of the experiment varies but little, the time and energy spent at the glass fluctuating somewhat from day to day, depending perhaps in some degree on the keenness of their hunger. Their efforts on Mondays were noticeably more determined than on Wednesdays and Fridays, because, it would seem, of the added day's fast. They never failed to try for the minnows to some extent, especially during the first half of the thirty minute period, but with waning energy and persistence. In this manner the trials proceeded for a month. On May 22nd I note: They pay no attention to the minnow till some time after I have placed myself behind the screen. They are less demonstrative than on any previous Monday.

I now determined to admit the minnow, and after the appetite of the perch had been dulled a very little with worms, the partition was removed. The minnow swam around with the perch, over and between them. Having lost its own mate, it perhaps sought companionship. The male paid not the slightest attention to it. The female, whose persistence at the glass has been noted, moved toward it several times, but whether from curiosity or with hostile intent could not be determined. She did it no harm however. On succeeding days the minnow was admitted in the same way, and the actions of the perch toward it were closely observed. On the second occasion they had been fed little and were still hungry. The minnow hovered near them as if for companionship, but all the time was a little wary. Several times they started to stalk it, but when within a short distance of its head would turn aside, the impulse being plainly inhibited in the face of repeated opportunity. In the

subsequent trials the perch were unfed. Their action, nevertheless, was always much as has been indicated. Sometimes they would swim around the aquarium apparently quite indifferent to the minnow, which accompanied them, but the sight of it moving in front of them would often stimulate the truncated attack already described.

The form of the experiment was now somewhat changed, being performed as nearly as possible after the manner of Möbius. The minnows, the one used before and a new one, were left for a week in the tank, separated from the perch by the glass. The latter ceased almost entirely to touch the glass, although quite frequently they took a position near it and watched the minnows playing on the other side within two or three inches of them. Their conduct when the partition was removed was exactly similar to that in the previous experiments.

Bateson, in the article above mentioned, suggests that the result of the experiment of Möbius may have been wrongly interpreted, and that "the explanation should be referred to that paradoxical instinct which is widely developed among animals of many kinds, in obedience to which they occasionally do not eat or molest those with whom they are constantly associated. It is, of course, this unexplained instinct upon which the 'happy family' of the travelling showman is constructed." In the case of these perch, however, the "happy family" theory will hardly serve. The perch's whole attitude is expressive of a desire to catch the minnow, a task which has come, however, to be regarded as hopeless. Such an explanation is also made less plausible by the fact that different minnows of different size were tried in the course of the experiment. And, indeed, habituation by constant association is hardly to be considered here; for the minnow, at least in the first series of experiments, was exposed to the sight of the perch but a short time each day, and at the period of greatest hunger, which furnishes in itself the strongest possible stimulus, not to the production of feelings of friendliness, but to the calling forth of savage instincts. That they were acting under the suggestion of their previous failures seems, in the light of the facts observed, the most reasonable explanation. The following incident is confirmatory of this. Toward the close of the work, when the perch had ceased to bump the glass in their efforts to reach the minnows, some angleworms were thrown into the tank on the side of the partition opposite the perch and lay squirming on the floor. The fish dashed violently against the partition in their effort to reach them, and beat the glass energetically for some time.

Their behavior in the presence of a strong suggestion, counter to their newly acquired habit, also militates against the view offered by Bateson. About the end of the third week,

while attempting to remove one of the minnows from the aquarium, it slipped through a crevice at one end of the partition into the part occupied by the perch, and dashing directly toward them in its flight was snapped up like a flash. The rapidity of its movement was probably the prime incentive, and called out the normal tendency to strike, before the later acquired inhibition could come into action. This minnow, or its mate, had gained entrance to the perch in the same way a few days previously, but in this case in a less exciting manner. The perch, aside from the female's nudging its tail twice, paid no attention to it, although it swam around them and under their very noses.

The restraining influence under which they were acting was again broken a few days later. Circumstances made necessary the omission of the test till two days after the regular period had passed. They were therefore wild with hunger and the opportunity for observing a conflict of impulses was of the best. The minnow was admitted, and at first was treated much as on other occasions. After a few moments, however, being evidently impelled by hunger, the perch became more demonstrative toward it, but restrained themselves from striking, so long as it quietly avoided them. Finally, however, being followed into a corner, it made a quick dart to escape, and this was apparently all that was required to wake the sleeping instinct, and a savage chase began which must have ended fatally to the minnow, had I not separated them. The perch were thoroughly aroused and all effect of their training seemed, for the time being, to be lost. A few more bumps at the glass during succeeding trials, however, restored the inhibition, and the final test made a little later showed it to be quite firmly impressed upon them. The minnows were removed from the sight of the perch for five days. To ascertain whether any effect of the training yet remained, they were then put directly into the compartment with the perch which had eaten nothing for two days. It was plain to the observers that the behavior of the latter had been greatly modified by the course of education to which they had been subjected. The first minnow put in soon attracted their attention. Their interest increased as they followed it about, and the female began to strike at it with growing boldness, and getting it into a corner finally secured it. The second minnow was greatly desired by the male, but he seemed utterly inefficient. He would trail it around and at times make feeble darts at it and then give up the attempt for the moment. In this way he was seen to nag it for nearly an hour. On returning to the tank after five hours the minnow was found swimming near the perch entirely unmolested. The male's experience had apparently so far inhibited his natural

reaction that he had ceased to try. As Paulsen remarks of the pike in Möbius's experiment, "he had manifestly made a law of nature for himself." A strike at the minnow had come to mean a bump on the nose for him.

In regard also to the general educability of fishes my observations are at variance with those of Bateson. He says with regard to the persistence with which the fish in the tanks of the Marine Biological Association beat the glass, and their slowness to profit by experience or to form associations: "None of the fish seem to get any lasting appreciation of the nature of the plate glass wall of the tank. The same fish will again and again knock the head against the glass in trying to seize objects moving on the other side. After repeated attempts to take food on the other side of the glass they will desist, but some of the oldest inhabitants (plaice, pollock and bream) which have been living in the aquarium for about a year, will perseveringly try again the next time." This was not the case with the perch under discussion. While these fish did not entirely cease striking the glass during the time when the trials were but thirty minutes long, their attempts grew very much more infrequent and their blows feebler. Later in the changed form of the experiment, becoming accustomed to the sight of the minnows, they gave up striking the glass, merely continuing to watch them. This, in connection with their conduct toward the minnows when the glass was removed, suggests that they have at least a strong temporary appreciation of the obstacle.

Another proof that they had formed a firm association with regard to it may be taken from the notes. On April 21st the partition which had been in position for several days was removed and the perch driven toward the place previously occupied by it. On reaching it they stopped and turned back. "On May 4th, glass removed in order to clean tank, but waited to see if fish would cross the line. The male swam out to the place, stopped, made little bumps forward as if expecting to strike the usual obstruction, and was plainly at a loss. He then turned and swam down as if following the glass." Ten days later with the same conditions they swam out to the mark several times, then turned and swam back. So on a later occasion when the glass was taken out they turned three times at the mark, but finally crossed in a hesitating manner.

During the period in which they had lived on minnows the perch remained indifferent to man, but when their diet was changed to angleworms they began to take such a deep interest in the experimenter that it was necessary to use a screen in the trials. This added considerable interest to the study, especially as regards their memory and time sense. After releasing the minnows the experimenter took his place behind the

screen, viewing the movements of the fish through a narrow slit, and they saw nothing of him for thirty minutes. During this period, however, he was not forgotten. The first half of the time was pretty fairly divided between the minnow and the screen. As shown by my notes a marked change took place in the last half of the half hour period. They spent a larger and larger portion of the time gazing out toward the screen. Circling the tank rapidly a few times with growing excitement they would return to the spot, snapping their jaws and flirting their tails, till toward the close of the period they had attention for little else than the appearance of the man behind the screen. The time sense here exhibited is probably in large part a feeding-time sense; they remembered with their stomachs. The rhythmic recurrence of internal sensations due to a regular feeding time may well account for the form of memory here involved.

The same hunger memory might possibly help to explain the stories of fish coming regularly at the sound of a bell to be fed. Bateson found, in the study before referred to, that most fish hear little or nothing of sounds in the air, but are affected by vibrations of the water and earth near it. The subject has also been carefully studied by Kreidl¹ and by Lee,² whose experiments are in agreement with his. Lee thus summarizes the case as presented in Kreidl's second paper: "Kreidl explodes the oft repeated tale of hearing by fishes that come for their food at the sound of a bell, by investigating carefully the action of trout at the famous old Benedictine monastery in Krems, Austria. He proved that the fishes come because they see the man who brings the food, and appreciate the vibrations of the water caused by his step and communicated through the stone basin; and that, when these are excluded, the sounds of the bell have no effect." The weight of recent authorities is thus against the existence in fishes of an auditory sense in the usual meaning of the term. My own observations, though not of a character to support an opposite conclusion, seem to me to require for their explanation the existence of a "sense of jar" of a delicacy at least equal to that of hearing. I made it a practice to whistle loudly while feeding the fish, and often while behind the screen I would use the whistle in the same manner. Very often at such times they would come directly to the side and look eagerly at the screen. Often they would turn only slightly in my direction; and in a very few cases they paid little

¹ Kreidl: Ueber die Perception der Schallwellen bei den Fischen, *Pflüger's Archiv für Physiologie*, Bd. LXI, p. 450, also Bb. LXIII, p. 581.

² Lee: The Functions of the Ear and the Lateral Line in Fishes, *American Journal of Physiology*, I, 1898, 128-144.

or no attention. Some gold fish in the laboratory, however, hardly ever failed to come at the sound of the whistle, especially if hungry. In regard to the fish feeding stories, it must be agreed, however, that the sight of the man ringing the bell is the chief factor.

Belonging to the group of fishes that find their food by sight, the perch possess great keenness of vision. They are so highly reflex, also, that the least visual perception of motion puts them into action. Two bright buttons kept in oscillation by the incoming water were a constant source of attraction to them. The swaying objects when caught in indirect vision seemed never to fail of bringing them to attention. Of course the trolling hook, with its revolving spoon of bright metal, depends for its efficiency on this deep seated interest in bright and moving objects.

These fish are very imitative, a movement in one almost surely producing a similar movement in the other. This trait is probably due to their primitive shoal life, where it was necessary to follow the crowd or fall a victim to the host of enemies on the outskirts.

To test their power of discrimination a species of wireworm was dropped into the tank alternately with small angleworms broken to the same length. The difference to sight was very small indeed. On one occasion when five were thus given, the first three were taken into the mouth and then rejected. The remaining two were permitted to sink to the bottom untouched. In subsequent trials the first wireworm has generally been taken into the mouth and the others neglected, the discrimination perhaps being aided by taste or possibly by the sense of touch in the mouth. The fish seemed, however, to make no fully permanent associations, but always to test the possibilities of such an object falling through the water.